SUPPLEMENT.

The Mining Journal,

RAILWAY AND COMMERCIAL GAZETTE:

FORMING A COMPLETE RECORD OF THE PROCEEDINGS OF ALL PUBLIC COMPANIES.

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MINERAL WEALTH OF CORNWALL AND DEVON.

To those acquainted with the vast mineral resources of this country it is unnecessary to mention that the counties of Cornwall and Devon stand pre-eminent for the production of copper and tin; whilst mines of lead, also of great richness, are to be found there—in fact, two-thirds of the yield of copper of the whole world is raised in these districts: but Nature, so bountiful in this and other valuable metals, has denied it the production of coal. The annual raising of copper ores is rather over 150,000 tons, averaging 7½ to 7¾ per cent., or 12,000 tons of the fine metal; the value of this exceeds 800,000*l.* sterling. The quantity of tin ore raised may be stated as 11,000 tons, containing 65 per cent. of the metal (say 7000 tons), which, valued at 90*l.* per ton, yields 630,000*l.* The annual production, therefore, of copper and tin together may be computed as amounting to 1,430,000*l.* sterling. For a period of four years—namely, 1850 to 1853, inclusive—this branch of our national industry shows an aggregate return of 5,720,000*l.*, a sum amply sufficient to place Cornwall and Devon at the head of mineral production, excepting in coal and iron, the annual value of which exceeds 15,000,000*l.* sterling; but these are more generally diffused throughout the country than copper and tin, being found in rich and widely-spread basins in most of the counties of England, Scotland, and Ireland; the former average 5s. 7d. at the pit's mouth, and the latter 48s.

The Cornish and Devon ores are conveyed to Wales for the purpose of smelting, therefore the sum of 2*l.* 15s. per ton is deducted for returning charges; this, on an annual yield of 150,000 tons, gives a drawback of 1,650,000*l.* for the four years, say 3,200,000*l.*, the total production for that period being equal to fully one-third of the intrinsic value of the metal itself, or one-half of the sum the miner receives for his ores, and from which he has to deduct the cost of labour, machinery, royalty, and all other expenses connected with mining operations. Fully one-half, or 825,000*l.* thereof, would be saved to the copper miner had he coal in his own district, and which would double the present amount of dividends received upon all the mines at work in Cornwall.

It appears that the copper and tin mines of Cornwall and Devon present the following results for the four years in question—viz., 61 in number, 56 situate in Cornwall and five in Devonshire; the former yielded, in dividends, 825,835*l.*, and the latter 109,912*l.*; this is 16·35 per cent. upon the aggregate yield of those districts for that period—namely, 5,720,000*l.* of ore, which also includes the produce of the host of young and progressive mines at work, notwithstanding they have contributed no dividends, having, in most cases, sustained calls; therefore, in justice, the per centage of profits should be increased to a proportionate extent, in order, accurately, to ascertain the true position of the dividend mines alone; at some future period it will afford me much pleasure to investigate the subject more elaborately. I subjoin the dividends paid by the copper and tin mines of Cornwall and Devon, showing the several amounts for the respective years in question:—

Mines.	1850.	1851.	1852.	1853.
Alfred Consols	£ 2,048	£ 9,472	£16,128	£20,736
Arthur	—	—	—	641
Balleswidden	3,451	3,247	1,948	2,307
Basset	14,080	14,360	21,768	30,720
Bedford United	4,000	4,600	4,000	4,700
Botallack	1,000	1,500	2,550	6,500
Buller	13,120	17,920	24,960	45,440
Calstock United	—	1,000	—	—
Carn Brea	13,000	9,000	6,000	12,000
Clifford	—	—	360	568
Comfort	768	—	—	—
Condurrow	1,280	512	2,304	4,608
Devon Great Consols	40,960	40,960	46,080	63,024
Dolcoath	—	—	—	2,595
Fowey Consols	1,976	—	—	—
Friendly	500	—	—	—
Friendship	2,880	1,536	1,024	3,584
Golden	—	3,250	1,250	—
Gonamena	—	—	256	—
Great Consols	960	—	—	—
Great Onslow	—	—	5,000	—
Great Polgooth	—	1,100	4,950	—
Great Work	4,165	2,975	3,451	2,082
Jane	—	—	256	1,792
Levant	4,000	3,040	320	320
Lewis	500	1,500	—	—
Lovel	860	3,440	4,300	1,720
Margaret	3,136	1,568	392	952
Marke Valley	—	—	—	750
North Basset	3,000	1,500	1,500	6,000
North Pool	14,250	9,000	5,500	7,000
North Roskear	2,800	4,270	910	2,380
Owles	—	—	996	4,040
Par Consols	12,800	5,120	15,360	4,800
Penzance Consols	128	—	—	—
Perran St. George	—	2,030	—	—
Phœnix	—	3,000	10,000	—
Polberro	—	2,680	—	3,283
Providence Mines	2,576	1,680	—	840
Reeth	3,000	3,000	2,500	—
Rix Hill	—	—	389	779
St. Aubyn and Grylls	—	—	896	—
St. Ives Consols	282	1,222	1,974	1,410
Seton	5,940	4,752	4,752	3,366
South Caradon	384	3,840	1,280	6,400
South Frances	10,478	10,416	6,696	6,076
South Tolgus	3,712	4,224	7,168	2,304
Spearne Consols	1,376	1,920	2,048	896
Stray Park	3,000	—	—	—
Tincroft	3,150	—	3,150	3,150
Trelyon	—	—	—	429
Tremayne	3,328	3,584	3,072	512
Trethellan	600	300	—	—
Treviskey and Barrier	8,760	6,780	4,770	540
Trumpet Consols	—	500	2,000	2,000
United Mines	1,000	500	5,000	11,600
Wellington	1,024	768	—	—
West Caradon	1,920	4,224	7,424	10,496
West Providence	1,024	2,560	10,752	6,656
West Darlington	—	—	—	256
West Treasury	—	—	—	1,024
Total	£197,216	£199,850	£245,434	£293,247

1850	£197,216
1851	199,850
1852	245,434
1853	293,247
Total	£935,747
56 Cornwall companies	£825,835
5 Devonshire companies	109,912
61	£935,747

Of the above 56 Cornish mines, 13 are situate in the Camborne, Illogan, and Redruth districts, which I purpose especially to remark upon, and which contributed the large proportion of 375,111*l.* towards the 825,835*l.*, being 45 2-5ths per cent. of the dividends of the two counties of Cornwall and Devon:—Buller paid 101,440*l.*; Basset, 81,928*l.*; Carn Brea, 40,000*l.*; North Pool, 35,750*l.*; South Frances, 33,666*l.*; Seton, 18,810*l.*; South Tolgus, 17,408*l.*; North Basset, 12,000*l.*; North Roskear, 10,360*l.*; Tincroft, 9450*l.*; Condurrow, 8704*l.*; Stray Park, 3000*l.*; Dolcoath, 2595*l.* = 375,111*l.*

The Carn Brea hills stretch from the town of Camborne to Redruth, and are composed of granite, with basins of killas, or clay-slate, in the valleys both to the north and south. Those to the north are the more extensive of the two, and are bounded by the Bristol Channel. The strata, which is subject to frequent changes, and of a varied character, is traversed by numerous east and west and caunter lodes, intersected by many cross-courses, elvans, deposits, and channels of ironstone, quartz, and decomposed granite, which affect and more or less influence the lodes at the several junctions. These also exist to an equal extent in the uneven and mineralised valleys to the south. The mines to the north, however, are more in number and of greater extent and antiquity than those to the south, although the latter are at present of more commercial value and importance. It is owing chiefly to the indefatigable perseverance and energy of Captain Lyle that this channel of ground has lately become developed, and who is now deservedly reaping a rich return for past patience and capital, in the receipt of dividends from West and North Basset, two of the most valuable permanent mines in this district. From the summit of Carn Brea hill we have a view of this district, divided in two by a range of granite hills running east and west; and who can witness the vast fields of machinery erected, and the thousands of busy operatives at work, without wishing success to British mining for the benefit it confers on the working population, irrespective of the profit yielded to the capitalist?

Carn Brea Mines are situate at the northern base of the hills of the same name, in the parish of Illogan, and consists of 1000 shares, 15*l.* paid, and which was laid out under the practical supervision of Mr. Lyle. The mines had been previously worked and abandoned, through want of energy in the adventurers, although immense returns and profits had been yielded. Its present success, after being neglected for a number of years, demonstrates that our forefathers wanted that experience and enterprise which under a more judicious, liberal, and extensive management, has led to the following brilliant results:—

The present company commenced operations in the year 1832. Since which, to the end of 1853, it divided 225,500*l.* profits—just 15 times its capital, or 7516*l.* 13s. 4d. annually, over 50 per cent., for a period embracing 30 years. The profits divided are as follows:—up to 1849, 187,500*l.*; 1850, 11,000*l.*; 1851, 9000*l.*; 1852, 6000*l.*; 1853, 12,000*l.* = 225,500*l.* The mines would, therefore, appear to be improved; for whilst the average of the past 30 years show only 50 per cent., last year gave 80 per cent. upon the capital subscribed. The present price of the mine is 80,000*l.*, or 80*l.* per share, which is equal to 6 2-3d years' purchase upon last year's returns—viz., 15 per cent. per annum upon the current price of the property. At the commencement of 1850 the cost-book presented the following results:—The machinery must have cost over 70,000*l.*, nearly all of which was supplied from the profits of the mines, in addition to the dividends paid. The mines produce copper, tin, and arsenic.

Dr.—Capital paid up	£ 15,000	0	0				
Copper ores sold	801,323	0	0				
Tin ores sold	109,441	0	0				
Arsenic, stores, interest, &c.	4,752	0	0	=	£930,516	0	0
Cr.—Labour cost and machinery	£667,335	0	0				
Management	6,527	0	0				
Lords' dues, or royalty	37,821	0	0				
Sundries	13,153	0	0				
Dividends	187,500	0	0				
Balance in hand	18,180	0	0	=	930,516	0	0
Addenda—Dividends to 1849 and part of 1850	£187,500	0	0				
1850 to 1853 (inclusive)	38,000	0	0				
Present value of mine	80,000	0	0	=	£305,500	0	0
Deduct capital paid up					15,000	0	0
Profit					£290,500	0	0

From this mine, I pass west to Tincroft, Cook's Kitchen, and Dolcoath, with Stray Park and Camborne Consols adjoining.

Tincroft, in its constitution, is an exception to the others; it is a scrip company, whilst its neighbours are conducted upon the Cost-book System. This sett lies between Carn Brea on the east and Cook's Kitchen on the west, with East Crofty and East Pool on the south. The capital subscribed amounts to 42,000*l.*, in 6000 shares, 7*l.* paid; and it has produced close upon 500,000*l.* worth of minerals during its present working, although the profits divided amongst the shareholders do not exceed 41,550*l.* It is a melancholy instance of a London management interfering injudiciously, and unfairly controling the practical working of the mines, thus rendering negative the efforts of successive local agents to regenerate its position. The property may, however, still be retrieved, if attended to in time.

Cook's Kitchen is a small sett, on the run of the lodes, but it has proved a most profitable piece of ground—the veins have been productive from one end to the other. It is one of the most ancient mines now at work, and upon a comparatively small capital (say 10,000*l.*) has returned profits exceeding 300,000*l.* The property is now of little commercial value, and is existing upon returns which, in its days of palmy prosperity, were deemed of slight consequence.

Dolcoath Mine is situated to the west of Cook's Kitchen, and has of late years been under the practical management of Capt. Charles Thomas. During the past two years its prospects have much improved, and last year it resumed paying dividends, after a cessation of 14 years; during this period, however, it was worked upon an extensive scale, and although the shareholders received no profits, the district was much benefited through a large portion of its population being employed, and the merchandise necessarily consumed. At a meeting held in March, 1853, the following facts were stated:—The balance at the next account is expected to be from 1200*l.* to 1400*l.*, and should the price of metals continue, dividends of from 4*l.* to 5*l.* may be calculated upon quarterly. A singular circumstance was referred to at this meeting; the manager stated that, within the last half century, this company had sold 3,000,000*l.* sterling of mineral, equal to 5000*l.* per month for the whole of that period, and that deducting capital subscribed by the shareholders, they had received profits exceeding 130,000*l.* Devon Great Consols, now the largest and most profitable mine of the day, is thus represented in contrast,—viz., that it will take more than 30 years, with her present returns, to equal the above amount; the profits upon the former mine have been as much as 3500*l.* per month. The North Tincroft lode runs through the entire sett, and if cut good at the deeper levels, the company may again experience some of its former prosperity.

To the north of Carn Brea are East Pool, Tehidy, Wheal Agar, and North Pool; and to the west of the latter, and parallel with Tincroft, Cook's Kitchen, Dolcoath, and Stray Park, are the following mines:—East Crofty, North Roskear, Wheal Seton, and West Seton, all of which are highly profitable companies.

East Pool consists of 128 shares, upon which 24*l.* 5s. is paid, and profits have been yielded of 238*l.* per share, thus returning 30,464*l.* against an outlay of 3104*l.* The present value of the mine is 16,000*l.*, although at one time it sold for upwards of 70,000*l.* This sett was, through breach of faith, surreptitiously withheld from the East Wh. Crofty shareholders.

Tehidy and Wheal Agar adjoin each other on the course of the same lodes, and considerable money has been expended in developing the works, but hitherto with little success. North Pool lies to the north—Carn Brea to the south, the cross-courses of which pass through the grants. The most that can be said in their behalf is, that they possess analogy and position in their favour.

North Pool is situate in the parish of Illogan, and commenced paying dividends in the year 1847. It consists of 200 shares, upon which 22*l.* 10s. is paid. The lodes are those of East Crofty, and probably North Roskear. It became at an early period of its existence profitable—in fact, the deposit of ore was discovered at the adit level, and it has since continued productive. The following dividends have been paid:—1847, 1000*l.*; 1848, 7750*l.*; 1849, 11,750*l.*; 1850, 14,250*l.*; 1851, 9000*l.*; 1852, 5500*l.*; 1853, 7000*l.*: total, 56,250*l.*

East Wheal Crofty has lately been divided into two mines, denominated North and South Crofty, and been subjected to several calls, the necessity and policy of which are much questioned. Captain Nicholas Tredinnick formerly superintended the works, and gave, upon an outlay of 11,900*l.*, 78,960*l.* profits. At this time, the Vice-Warden of the Stannaries Court remarked that it was a forcible example of the favourable working of the Cost-book System. It is now, however, differently conducted, and of little commercial value.

North Roskear adjoins the East Crofty, Seton, and West Seton setts. It is under the same management as the North and South Crofty Companies, and has been for many years a most profitable adventure. The capital subscribed was only 1400*l.*, and the profits divided to end of 1853 amounted to 35,000*l.* The shares are 140 in number, and are worth 125*l.* each.

Wheal Seton commenced paying dividends in 1846, and has continued annually to pay sums ranging from 11,880*l.* to 1584*l.*, and the price of shares have fluctuated from 450*l.* to 150*l.* per 1-198th share; the present price is 200*l.* The mine is situate in the parish of Camborne, is surrounded by numerous profitable mines, is *bona fide* and permanent in its character and constitution, has a large and efficient field of machinery created, and is worked with a view of yielding the proprietors dividends from legitimate profits, regardless of market operations in shares, whilst, from present prospects, it is likely to continue long productive and profitable. The original outlay upon this mine was 21,186*l.*, and the total dividends paid amount to 49,599*l.* The shares are now 198 in number, but were originally only 100. One of the shareholders becoming faint-hearted, shortly before the lodes became productive, relinquished his share; hence they were reduced to 99, and from subsequent division increased to 198. Dividends paid:—1846, 8910*l.*; 1847, 11,880*l.*; 1848, 8415*l.*; 1849, 1584*l.*; 1850, 5940*l.*; 1851, 4752*l.*; 1852, 4752*l.*; 1853, 3366*l.* = 49,599*l.*

West Seton has a continuance of the Seton and North Roskear lodes, and commenced paying dividends during the present year; 2000*l.* has been divided amongst the shareholders in two dividends, of 1000*l.* each. It is a model of what a mining company ought to be—well held, spiritedly worked, and well conducted (since the present purser has had the management of its affairs). It is marketable at 40,000*l.*, against a subscribed capital of 15,400*l.*

Camborne Consols contains some of the Dolcoath lodes, and adjoins it. It is a valuable piece of mineral ground, is practically managed, and the shareholders are good; it is at present in a favourable position of progression. The additional capital required will not be considerable.

Stray Park.—This mine is under the management of Mr. Vawdrey, whose career testifies that he knows more of the theoretical than practical management of mines. It has either proved a most deceptive piece of ground, or has been worked more for market operations than dividends from legitimate mining.

The foregoing are the results of mining adventure on the north side of the Carn Brea Hills. Observe the following statistics:—

Mines.	Outlay.	Divid. to end of 1853.	Market value.
Wheal Agar	£6,000	—	nil.
Camborne Consols	2,000	—	£30,000
Carn Brea	15,000	£225,500	80,000
Cook's Kitchen	—	300,000	nil.
Dolcoath	46,137	156,302	10,000
East Crofty	11,900	78,960	nil.
East Pool	3,104	30,464	16,000
North Pool	4,500	56,250	30,000
North Roskear	1,400	35,000	16,000
Seton	21,186	49,599	40,000
Stray Park	10,375	12,500	7,500
Tehidy	15,000	—	2,500
Tincroft	42,000	41,550	12,000
West Seton	15,400	2,000	40,000
Total	£194,002	£988,125	£284,000

(All of the above mines are situate in the parishes of Camborne and Illogan.)

We now proceed from Camborne up the hill to Condurrow and Wheal Harriett, which are situate entirely in granite, and from thence to the mines on the south side of the Carn Brea Hills. The former mine is under the able management of Capt. Nicholas Vivian, who has erected considerable machinery, in addition to giving the under-mentioned profits since the year 1848—viz.: 1849, 1536*l.*; 1850, 1280*l.*; 1851, 512*l.*; 1852, 2304*l.*; 1853, 4608*l.* = 10,240*l.* This company is divided into 256 shares, and the capital subscribed amounts to 5120*l.*; it has, therefore, repaid the outlay, with 100 per cent. profit. It is now marketable at 110*l.* per share, or 28,160*l.* for the whole property.

Wheal Harriett progresses slowly, and, in my opinion, they are working the wrong end of the sett.

Parallel with these two mines are South Condurrow, Wheal Grenville, and Bolenowe, through which one of the Dolcoath cross-courses must pass, and all of which are likely to become productive and profitable mines.

East of Condurrow, South Condurrow, Wheal Grenville, and Bolenowe are West Basset, West Frances, South Frances; and still further east are North Basset and Wheal Basset, which stand directly south of the Carn Brea Mines.

To the east of Wheal Basset is the celebrated Buller Mine, to the north-east of which are Penstruthal and Treasvean Mines; whilst to the west of the latter two, and parallel with Basset and South Frances, is the grant of the Buller and Basset United Mining Company.

West Basset consists of 6000 shares, and the capital expended is about 10,000*l.* It has, during the present year, paid 9000*l.* in dividends, and is said to be in a most efficient state of working, and to have very great reserves of ore in store. It will probably pay 20,000*l.* in dividends during next year. Its present market value is about 200,000*l.*

West Frances is a very small sett; yet, having the South Frances main lode passing through it, is deemed a property of much promise: the

engine-shaft is sunk 70 fms. below the adit level, yet, hitherto, the only produce has been tin.

South Wheal Frances stands directly south of West Basset and West Frances, and north of Basset and Buller United. The great cross-course, which has made so much ore in its progress through Wheal Seton, North Roskear, Dolcoath, and Cook's Kitchen, West Basset and South Frances, passes into Buller and Basset United, intersecting the Penstruthal and Tresavean lodes, near its western boundary. It is, doubtless, owing to the influence of this cross-course that the lodes in West Basset and South Frances have proved so productive; the capital paid up upon this latter mine amounts to 9393*l.*, whilst the market value is 38,000*l.*, and the dividends yielded to the end of 1853 amount to 58,094*l.*; this property is of a very permanent character, and will most probably improve in value as time develops its great extent of virgin ground. Dividends paid:—1845, 992*l.*; 1846, 744*l.*; 1847, 9796*l.*; 1848, 5704*l.*; 1849, 7192*l.*; 1850, 10,478*l.*; 1851, 10,461*l.*; 1852, 6696*l.*; 1853, 6076*l.*

A very powerful and efficient steam pumping-engine was erected upon this mine by Mr. Nicholas Walter Tredinnick, which stood for some years first, for duty, in the list of Lean's *Cornish Engine Reporter*.

North Basset stands south of the Carn Brea Hill, opposite to Carn Brea Mines, on the north side. The cross-courses of the latter mines in proceeding north intersected the lodes of East Pool and North Pool—both of which have been very productive of copper; these same cross-courses pass south through South Carn Brea sett, which is the granite hill before referred to, and divides the North Basset and Carn Brea Mines, into North Basset Mine, thence to Basset, and on to Buller and Basset United beyond. The money subscribed by this company amounts to 10,000*l.*, and the dividends divided hitherto have not been large; but from discoveries recently made, they will probably much improve. The shares are 6000 in number, worth 20*l.* per share, or 120,000*l.* for the property.

Wheal Basset is in extent about 600 fms. square. Operations were first commenced in the year 1832, and have been continued up to the present time. A new lease for a further period of 21 years was obtained as lately as the year 1851 from Lady Basset; its position is between Buller and South Frances Mines, with Buller and Basset United lying immediately to the south. The quantity of copper and tin ores sold to the end of 1850 amounted to the large sum of 280,000*l.*, and the profits yielded are as follows:—

To the end of December,		1845	£35,840	0	0
Ditto	ditto	1846	1,280	0	0
Ditto	ditto	1848	1,280	0	0
Ditto	ditto	1849	6,400	0	0
Ditto	ditto	1850	14,080	0	0
Ditto	ditto	1851	15,360	0	0
Ditto	ditto	1852	21,760	0	0
Ditto	ditto	1853	30,720	0	0
Total			£126,720	0	0

This property is one of the most valuable in Cornwall; the ores are rich in bulk, realising considerably above the average of the county. The shares are 256 in number, and are at present marketable at 600*l.* each. The company is likely to receive dividends for many years to come; the lodes being numerous, and the reserves of ore being large throughout the mine.

Market value, 256 shares at 600*l.*	£153,600	0	0
Dividends to end of 1853	126,720	0	0
Total	£280,320	0	0
Deduct subscribed capital	2,624	0	0
Total value	£277,696	0	0

Wheal Buller adjoins Basset and North Basset setts; the former stands to the due west, and the latter a little to the north and west. It is about 200 fathoms from the Penstruthal sett, and 225 fathoms to the north-east of Buller and Basset United Mines. Penstruthal adjoins the Tresavean Mine, and the lodes of these two latter mines, which have produced as much copper as any lodes in Cornwall, traverse Buller and Basset United grant for upwards of 800 fathoms in length. The Buller sett is about 600 fathoms in length, and only 300 fathoms wide; it was put to work only in the year 1848, under the practical supervision of the Messrs. Richard and Stephen Davey, of Redruth, and has since produced the following results. This grant was formerly held by a London mining house, and abandoned by it as worthless. In its progress, no mine in Cornwall of late years has been so rapidly developed, and placed so soon at the head of produce and profits. The principal lode became productive at a shallow depth, yielding 20 tons of ore per fathom, at 20 fathoms only below the adit level. The capital subscribed was only 1280*l.*; the amount of dividends yielded to the end of 1853 was 104,000*l.*, when the shares (256 in number) sold for 1000*l.* each; they have, however, much depressed in market value, chiefly from the depressed state of the money market, and the difficulty of negociating such large shares when the enterprising public is paralysed through the effects of the present war.

Dividends paid—1849	£ 2,560	0	0			
Ditto —1850	13,120	0	0			
Ditto —1851	17,920	0	0			
Ditto —1852	24,960	0	0			
Ditto —1853	45,440	0	0 =	£104,000	0	0
Value of property end of 1853				256,000	0	0
Total				£360,000	0	0
Deduct capital				1,280	0	0
Profit				£358,720	0	0

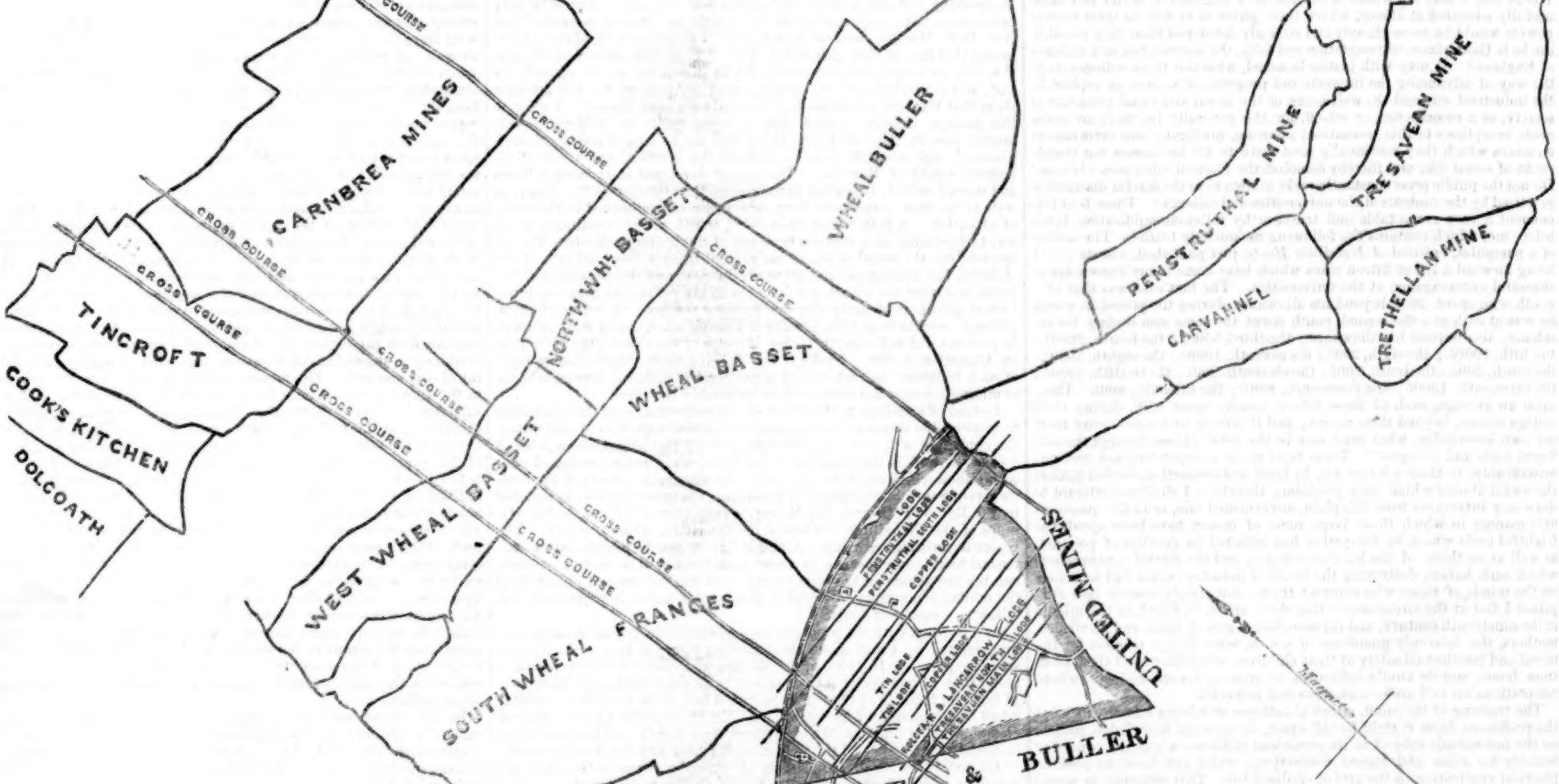
Tresavean.—This mine, abandoned as a failure, was taken up by the late Capt. Thomas Teague, who persevered in exploring it, and with an outlay of little more than 1000*l.* succeeded in discovering its wealth, and its continued prosperity offers another instance of fortunate mining adventure. The mine is a very dry one, the lodes are chiefly in granite, becoming profitless when they quit it and pass into killas. Under different companies this mine has divided upwards of 800,000*l.* From the year 1814 to June, 1848, it returned the enormous quantity of 307,970 tons of copper ore, which realised 1,879,735*l.* 7s. 6d. The present company is divided into 96 shares, upon which 3120*l.* is paid up, and was formed about 25 years ago; it has netted a profit and divided amongst the shareholders 452,790*l.*, and the property is now worth about 20,000*l.* as dividends having been paid since the year 1847 until a month ago, when it paid 5*l.*, and promises to continue doing the same bi-monthly. The highest amount of dividends paid was in the year 1833, when 60,480*l.* was divided amongst the shareholders. At this time the shares were negociable at 2000*l.* each, 20*l.* paid. This amount of profit has since been exceeded by the Devon Great Consols, which declared dividends last year amounting 65,024*l.* The capital subscribed upon this latter mine is only 1024*l.*; it is now saleable at the enormous sum of 425,000*l.*, and has paid in dividends from 1844 to 1853, inclusive, a period of 10 years, the large sum of 375,808*l.* But, returning to the former mine, in 1834 it divided 47,040*l.*; in 1836, 48,000*l.*; in 1839, 33,000*l.*; in 1840, 18,720*l.*; from which period they gradually diminished for seven years, when they ceased altogether. These lodes have been also profitable in the adjoining mines of Trethellan and Treviskey and Barrier.

The Penstruthal Mine adjoins the former, and lies between it and the Bullers; it has, however, been suspended for several years, after making very large profits. I have no means of ascertaining, with any degree of accuracy, the amounts yielded, therefore will content myself with observing that report states it to have been the richest mine of the day, and concurrent with it there existed some of the most profitable mines which Cornwall ever possessed; it sold 60,000*l.* worth of mineral in two months, and divided in one year more than either Tresavean or Devon Great Consols, whilst its profits probably exceeded over a series of years 500,000*l.* The operations were chiefly limited to one lode, although two or three side or parallel lodes were known to exist; and from some unaccountable cause, which probably will never be correctly explained or ascertained, the works, as the first bunch of ore became exhausted, were neglected, and at last suspended, with prospects of making further discoveries unequalled by two-thirds of the mines ever at work. It affords me much pleasure, however, to remark that an intelligent and active Scotchman, for some years resident at Redruth, has purchased the property, and is about to re-open the mines, with an adequate capital. I heartily wish Mr. Little success in his undertaking.

Statistics of mining adventure on the south side of Carn Brea hill, with the mines just to the east thereof, and surrounding the Tresavean:—

Mines.	Outlay.	Divid. to end of 1853.	Market value.
Basset	£2,624	£126,720	£153,600
Buller	1,280	104,000	153,000
Condurrow	5,120	10,240	28,160
North Basset	10,000	12,000	120,000
Penstruthal	5,000	500,000	Stopped.
South Frances	9,393	58,094	38,000
Tresavean	3,120	452,790	20,000
Trethellan	900	48,441	—
Treviskey and Barrier	15,600	37,000	—
West Basset	10,000	9,000	200,000
Total	£63,037	£1,358,258	£712,760

I subjoin a map of the district, surveyed by Mr. R. Symons, the mineral surveyor, of Truro, Cornwall:—



BULLER AND BASSET UNITED COPPER MINES.

Consisting of 256 shares.—Balance in hand, 3976*l.*—Conducted on the Cost-book System.

Local Manager: Capt. Peter Floyd.—Offices: 4, Austinfriars, London.

These mines are situate in the parish of Wendron, in the county of Cornwall, and are held direct from the Duchy. The grant is most extensive on the course of the lodes, all of which are proved to be highly mineralised. To the east of the company's sett are the Penstruthral and Tresavean Mines, which, upon an outlay not exceeding 8120*l.*, have returned copper ores to the amount of 4,000,000*l.* sterling, and divided profits exceeding 1,250,000*l.* The lodes of these mines traverse Buller and Basset United sett for upwards of 1600 yards in length, and which are intersected by the Carn Brea, North Basset, and Basset cross-courses, near its eastern boundary, and within 40 fathoms of the western limits of the grant the great cross-course passes, which have made so much copper ore in the undermentioned mines—viz., Seton, North Roskear, Cook's Kitchen, Dolcoath, and South Frances.

Mr. Tredinnick, the London representative of the company, is to meet Capt. Floyd, and several of the agents of the chief mines of the district, upon the ground, on Monday next, when operations are to be actively commenced.

I have the honour to be, Mr. Editor, your humble servant,

4, Austinfriars, Nov. 24, 1854. R. Tredinnick.

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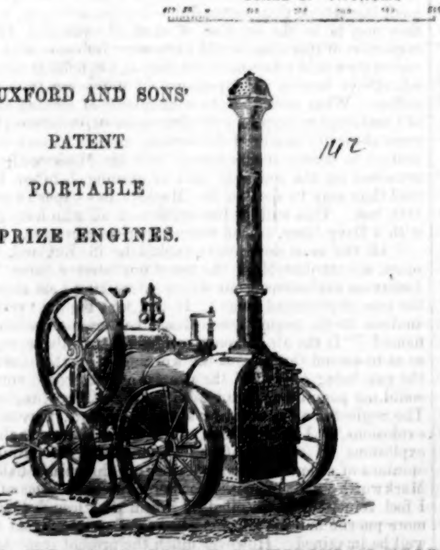

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IMPROVED RATCHET JACK. HALEY'S PATENT LIFTING JACK.

Original Correspondence.

ACCIDENTS IN COAL MINES.

TO THE EDITOR OF THE MINING JOURNAL.

SIR,—Having in my former letters fully exposed the utter worthlessness of the recommendations of the late committee of accidents in coal mines, the flagrant absurdity of the vaunted phrase *scientific viewer* as applied to the present managers of collieries and Government inspectors, the many evils attached to, and, indeed, inseparable from, the establishments of mining schools, and also their inadequacy to supply useful, effective, practical, and scientific men to develope and sustain the resources of the mineral wealth of this country, I shall again avail myself of every true Englishman's dearest and most cherished privilege, full freedom of thought, and, in defence of honest labour, raise my humble voice against the powerful and too successful oppression of acquisitive, grasping, and avaricious capitalists, and conceited, in the full sense of this word, college aspirants. Fellow workmen, listen to one who has been brought up from infancy amongst you, laboured with you many years, and shared your hopes, joys, fears, disappointments, and aspirations. The best advice which I have now to give you is this, that you should by all means make every possible effort to educate yourselves and your children; your own powers, I am fully persuaded, are alone sufficient to accomplish this desirable object, and let me tell you it is the only hope of future freedom from the tortuous meshes which have been, and still are being, thrown around your toilsome path. Learn to despise the gaudy glitterings of wealth, which has been too frequently accumulated at the expense of suffering humanity, the orphan's tear, and the widow's sorrow. "Envy thou not the oppressor, and choose none of his ways." In my last letter I particularly referred to the establishment of mining schools, and pointed out clearly to unprejudiced minds their many and glaring defects, as a means of diminishing the fearful accidents which all must deplore, and improving the present rude and primitive modes of obtaining coals. Surely the great object aimed at by the advocates of mining schools is the improvement of the moral and intellectual condition of the collier, the diminution of those frightful chasms which fatal accidents cause in the social compact, and which appear at present to be inseparably connected with mining practice, and not the increase of a slight per centage to gratify the morbid sensibilities of unfeeling accumulators of wealth, which is done in too many cases by questionable means. Whatever may be the plans devised for the successful prosecution of mining schools, whatever may be the calibre of the professors engaged in them, however pure and disinterested may be their motives, I repeat again, college students, apart from labour, will fail, as they always have, to accomplish any of these objects.

I now most respectfully appeal to the patriotism, justice, and sound discretion of the noble lord, at the sound of whose name the despots of Europe tremble, if the education of the artisan and the collier be an object of anxious solicitude, as represented in the speeches of the noble lord, the President of the Council, and other influential members of the Government and the House of Commons, whether this "consummation devoutly to be wished for" may not be best accomplished by the Government rewarding the exertions of self-moved industry, instead of bestowing its patronage in profusion on successful schoolboys, who have never contributed by their physical labour to the welfare and honourable maintenance of the State? Would not, I ask, the whole of the youth of England be better and more usefully educated at labour, where their physical as well as their mental powers would be more cheaply and strongly developed than they possibly can be in those places of temptation and folly, the universities and colleges of England? It may with justice be asked, what is it these colleges do in the way of advancing the interests and progress of science as applied to the industrial arts and the well being of the moral and social condition of society, as a recompense, or set-off, for the generally (as there are some noble exceptions to this accusation) cunning, profligate, and extravagant members which they continually send forth to fill the honest but simple ranks of social life, and thereby demolish the fruits of other men's labour? Do not the public press constantly make known to us the fearful dissipation practised by the students of the universities and colleges? There is at this moment a very respectable and trustworthy religious publication lying before me, which contains the following melancholy truths. The author of a pamphlet, entitled *A Few Plain Hints*, just published, asserts:—"I bring forward a list of fifteen cases which have come to my knowledge of shameful extravagance at the universities. The first case was that of a youth who spent 200*l.* beyond his allowance during the period in which he was at college; the second youth spent the same sum during his residence, also beyond his allowance; the third, 1500*l.*; the fourth, 2000*l.*; the fifth, 1000*l.*; the sixth, 200*l.*; the seventh, 1000*l.*; the eighth, 2000*l.*; the ninth, 200*l.*; the tenth, 200*l.*; the eleventh, 200*l.*; the twelfth, 1000*l.*; the thirteenth, 1500*l.*; the fourteenth, 800*l.*; the fifteenth, 800*l.* Thus, upon an average, each of these fifteen youths spent 850*l.* during their college course, beyond their means; and if fifteen such cases could meet my own knowledge, what must now be the total excess through the different halls and colleges?" These facts speak trumpet-tongued, and unmistakeably, to those who are not, by birth and connection, steeled against the awful abuses which they proclaim; therefore, I shall not attempt to draw any inferences from this plain, unvarnished tale, as to the questionable manner in which these large sums of money have been spent, the frightful evils which its dissipation has inflicted on families of position, as well as on those of the humble cottager, and the fearful consequences which such habits, destroying the fruits of industry, never fail to induce on the minds of those who contract them; but simply remark how surprised I feel at the circumstance that there are to be found, in the middle of the nineteenth century, and the meridian of gospel, light, and privileges, mothers, the heavenly guardians of youth, who do not tremble for the moral and intellectual safety of their children, when they send them forth from home, and its kindly influences, to universities and colleges, where temptations for evil are so numerous and powerful.

The training of the mind, either at colleges or mining schools, in what the professors deem it right to call exact, or accurate knowledge, inflicts on the individuals subject to its pernicious influence a puerile, conceited tenacity for rules and logical distinctions, which can have no possible practical application in the arts of civilised life. This influence is manifested in various ways by the students, whose prolific genius frequently supplies us with ninety-nine different demonstrations of Newton's binomial theorem, parallelogram of forces, principle of work, virtual velocities, and D'Alembert's principle, with other profound investigations, leading to similar conclusions. Hence, one of the most distinguished professors at these colleges has been induced to send forth to a benighted world the results of his labours, in which he has been engaged for many years, with all appliances to boot. These important labours have for their object the settlement of the vexed question, "Are there more worlds than one?" I am not vain enough to attempt to decide the merits of Sir David Brewster's claims on the rolls of fame for an immortality in the ranks of Newton, Laplace, and Arago, of whose friendship he was justly proud; but, if I may be allowed to express an opinion, I frankly confess my conviction that there are exhibited every week, by the sons of toil, more ingenious inventions, more elaborate enquiries made, with a view to cheapen and increase the products of industry, than even those which resulted in the cherished law that the tangent of the maximum polarising angle is equal to the index of refraction. By the discussion of "Are there more worlds than one?" I am painfully reminded of the great and dazzling questions which formerly occupied so much of the valuable attention of the fathers and philosophers of the dark ages—"What colour and number were the frogs in Egypt that troubled the unfortunate Pharoah?"—"How many angels could dance a minuet on the point of a needle?" How these speculations tend to raise the intellectual and the social condition of mankind, I will not stop to determine.

The Astronomer Royal, too, is earnestly seeking to perpetuate his justly earned fame, not by *airy* flights (that would be too homely), but by descending the depths of the dark coal mines, and, with all the trappings which follow in the wake of wealth and position, he is about to immortalise his name in the execution of an experiment which could be undertaken with equal success by any schoolboy who has intelligence enough to read the face of a common house-clock. How admirably these appliances of wealth for such infinitesimal results contrast with the humble instruments of research which characterised the important labours of Dalton, Watt, Stephenson, Brindley, Arkwright, and a host of others! If the noble lord, the Home Secretary, has any patronage to bestow, could it, I ask, be better employed than in encouraging the toil-worn cottager in educating his children during the time their and his labours are assisting to maintain the present social state and power of England? What, in this respect, is done by college students can only be computed by means of differential and functional equations. I do hope, however, that the noble lord will reflect for a few moments on the instructive page of history, and observe the character of those monsters in human shape which figured so conspicuously in the National Convention of 1792, and also on the mild and benevolent Vendeans who fought so bravely to stem the tide of horrors which was destroying the virtue and glory of France. Many of those monsters were disappointed collegiate aspirants; while the Vendeans, who fought nobly for the freedom of their religion, and the cause of humanity, were the honest sons of labour. I feel no hesitation in saying that all promotion, to be beneficial, should rise nobly through the purifying channels of physical labour. Many of your correspondents, I am happy to see, agree with me in several of the principal points which are indispensable in the qualification of mining agents and Government inspectors. All unanimously condemn, as inefficient, and fraught with disastrous consequences, the practice of introducing college aspirants, whose experience, either of the operations of mining, or the ways, habits, and sympathies of the men engaged in such hazardous enterprises, must rest on very limited resources indeed.

The letters of Mr. Wasley and Mr. Gill contain many views to which I can heartily subscribe; but it appears to me, at least, that they misconceive entirely the really theoretical capacities of the would-be theoretical men, without a shadow of experience, and also the powers of the workmen, if circumstances permit, to grapple successfully with theoretical difficulties, while combating with the practical duties of real services in the mine. If it was necessary, I could refer to and make honorable mention of remarkable examples which would correct their views on the subject of obtaining "mine agents practically and theoretically qualified."

For instance, will these gentlemen deny to me the privilege of discussing successfully, even with collegiate aspirants, whose productions were so severely censured in my last letter, and with scientific reviewers, the various scientific questions, either in the abstract, college-like, or in their practical application to facilitate the operation of industry? Will the readers of my remarks in the *Mining Journal*, on the evidence of Mr. Elliott, and the philosophical and mathematical lucubrations of Mr. Mackworth, ignore my pretensions to the qualification of examining the capabilities, both practical and theoretical, of these college gentlemen and scientific viewers, when they reflect on the circumstance of my being a hewer and "butty collier" of some years' standing? It would be quite unbecoming, and, indeed, unphilosophical, in me to write in such strains as these, if I had my own personal interest only under consideration; but quite the contrary is the fact; the principle I am to assert and develope is, that the education obtained in the pursuance of physical labour is much in advance, so far as utility is desirable, and not the incongruous claims of the cliques of party faction of that peculiar education obtained within the hallowed walls of colleges and universities. In every sphere of life the self-taught man displays his powers when rightly directed and properly estimated over the mere "parrot-like genius" of successful grammar-school boys; even in teaching they become more effective, teaching them, as it were, in their own peculiar walk. For the truth of this assertion we have the highest and most trustworthy testimony in Professor Moseley, certainly one of the most honest and distinguished members of the university:—"It has often been a subject of regret with me, that the most hopeful students in a training school are precisely those to whom, practically, the least opportunity is allowed of gaining instruction. Those qualifications which make them apt to learn, make them usually apt to teach."—Minutes of the Committee of Council on Education, 1853, p. 213. In speaking "of persons who, having had few or no opportunities of early instruction, have acquired late in life a taste for literary pursuits," the Rev. Prof. Moseley proceeds to remark, "it is to the work of the schoolmaster that men of this class first look." "To exclude them from it, now that it is no longer unremunerated and in disrepute, would scarcely be just, and it would be, in my opinion, most inexpedient, for it is amongst them that the best schoolmasters have always been found." I refer to this passage, in order to show that, if inducements are held out to self-taught men in the coal mines, there will not be long wanting efficient, practical, and scientific men to manage the practical operations of the mineral wealth of England. The conceit developed in training colleges and normal schools is beginning to exercise the attention of the clergy, as well as the most respectable laity, who feel much interested in the cause of education. A lady writes thus:—"I would prefer remaining as we are, to venturing on a mistress from one of the training schools. The respectability, the moral worth of our present teacher, her kind care of the children, her willingness and gratitude in receiving the assistance of the ladies who visit the school, are far more in my estimation than the intellectual quickness of many cleverer younger teachers, for whose abilities, perhaps, one has to pay the penalty of hearing much that is most offensive in pertness and self-conceit."—See Minutes of the Committee of Council on Education, p. 908. I refer to this as being an inevitable consequence of such training; and whether it is practised in colleges, normal schools, or mining schools, the result will be invariably the same.

Instead of acceding to the infamous recommendation of the committee to increase the salaries of the present and future inspectors of coal mines, the noble lord will earn the gratitude of every right-thinking member of society, as well as the blessings of the poor, who have no means of educating their children, if he will assist the charitable efforts of the coal-owners of South Staffordshire, in developing the prize schemes, as reported by the Rev. J. P. Norris, her Majesty's Inspector of Schools, in the Minutes of the Committee of Council on Education, 1853-4, p. 151. The report is thrilling with interest, and if the system be persevered in, and pushed to its consequences, in a few years there will be no lack of efficient mining agents of the proper kind; besides, the general elevation of the mining community to a higher standard of social improvement will follow as a matter of course.

As a contrast with the profligate expenditure of university students, before referred to, I may quote the following from the Rev. J. P. Norris's special report:—"In 1852, of the 40 boys who received money prizes, I found that 17 had invested their money in savings' banks, or otherwise; 11 had laid it out in clothes or in books; 5 had given it to their parents; 2 had been apprenticed by means of it. In 1853, of the 42 who obtained money prizes, I find that 20 had invested their money; 16 had laid it out in clothes or in books; of the remaining 6 I have as yet had no account."

Are not these results sufficiently encouraging, even to the most desponding, to justify the establishment of a similar system in the counties of Lancaster, Nottingham, Leicester, York, Durham, and other coal mining districts, instead of supporting mining schools, which will never realise the objects contemplated by their originators? Will not these youths, as they ripen to years of maturity, be better qualified, both as respects practical experience and theoretical knowledge of the right kind, as Government inspectors, than successful collegiate aspirants, however well tuned they may be in the solution of abstract equations, &c.? Two or three inspectors of this class would have more influence with the men, and consequently would effect more salutary and beneficial results, than a host of schoolboys having no experience of, nor sympathies with, the working collier. What would be the consequence of sending the senior wrangler of Cambridge to inspect a cavalry regiment, or a man-of-war? Is not the same absurdity practised by sending men to inspect coal mines who can write "on science in the mines," like Mr. Mackworth? More ridiculous nonsense on the practical part of mining I never remember to have read than may be seen in Mr. Mackworth's paper in your Journal of the 18th inst. This will be the opinion of all who have practically worked with a Davy lamp, or had much experience in seeing it used.

"All the most destructive explosions in England, for the last seven years, are attributable to the use of unprotected flame." Do not the most disastrous explosions occur where safety-lamps are employed—that is, in the case of protected flame? If not, why should every committee be so anxious in its enquiry respecting the absolute safety of the protected flame? "If the air currents, passing through the mine, were all arranged so as to ascend throughout the workings, from the lowest to the highest, the gas, being only half the weight of air, would run off of itself, and could not possibly accumulate; consequently, no explosion could occur." The neglect of this, we are told, "is the primary cause of nearly all the explosions." I thought that unprotected flame was the cause of all the explosions. I cannot, of course, pretend to determine the views and opinions of scientific viewers respecting the absurd hallucinations of Mr. Mackworth; but, in justice to the practical abilities of "butty colliers," I feel reluctantly compelled to affirm that less acquaintance with, and more puerile notions of, the practical details of coal mining could not well be imagined. However much the present inspectors may enjoy the confidence of a few coal proprietors, they are, for the most part, entirely destitute of those sympathies with the miners which are so essential to the successful development of any plans specially devised for their benefit and protection. There must be something wrong in the state of society when schoolboys, not in connection with labour, and whose intellectual calibre will not carry them beyond the dull routine of school lessons, are treated with greater consideration than the miner whose labours contribute so largely to the general weal of the state. Such a state as this demands the serious consideration of the legislator. I repeat, in conclusion, that *all promotions should be made through the channels of labour*: this would make it honourable and sought for, not despised as degrading, debasing, and low.—*Nov.* 20. COAL MINER.

ON COPPER SMOKE: ITS INFLUENCE ON THE PUBLIC HEALTH, AND THE DISEASES OF COPPER MEN.

We have received a very important "Report on the Copper Smoke, its Influence on the Public Health, and the Industrial Diseases of Copper Men," from the pen of THOMAS WILLIAMS, M.D., of Swansea. It is dedicated to Sir BENJAMIN HALL, President of the General Board of Health, and combines much varied information, physical, climatal, chemical, and mineralogical. The report relates to a district which, now rising into vast importance, not only exhibits all the conditions of a new colony or settlement, but promises to become, perhaps, the most densely peopled county in Britain. In the present population, the ruling minds, the master capitalists, the princely mine-owners, are of Saxon derivation; while the minor agents, the small, cautious capitalists, are Welshmen from every county in Wales, Irishmen of every part of Ireland, Scotchmen, and Englishmen from every corner of England. The work before us is devoted to the sanitary condition, domestic habits, the prevailing industrial diseases of this teeming population, the remediable evils of which they are the victims, the food upon which they subsist, and the manifold other influences under which they are placed. To the consideration of these grave questions the author brings high professional attainments, a spirit of ardent enquiry, and the advantages of an extensive range of study. The result is a production which reflects high credit on his talents and industry as a writer, and is likely to prove a valuable addition to the scientific, statistical, and medical knowledge which we possess respecting the mineral districts of Great Britain.

A century has raised the town of Swansea from the obscurity of a fishing village, or of a casual watering-place, to be the metropolitan centre of the copper trade of the world. Multiplying at the ratio of 80 per cent. in every 14 years, the district, embracing an area of ten miles in length, by an average of three in breadth, contains an active, thriving, and intelligent population of 80,000. Of this number more than 12,000 are colliers and copper men, and the future promises a still accelerating increase. Sandstone, shale, clay, and coal, constitute the elements of the soil under the town; while a stratum of detrital gravel, presenting an average thickness of 100 feet, forms the surface, coal veins appear along the line of low-water in the bay, and the relics of an ancient forest lie confusedly buried in the clay. Local legends assert that farms once flourished where the sea now breaks, and the submerged forest and clay appearing are probably geologic proofs of a slowly proceeding subsidence of the land. The fundamental rock is that intermixture of sandstones, shales, clays, and coal, known as the coal measures, containing numerous beds of coal, worked in the neighbouring districts—to the abundance and small cost of which the town is chiefly indebted for its copper smelting and other manufactories. Our author devotes several interesting pages to geographical details respecting the neighbouring country, its climate, and the configuration of the land, in determining the course of atmospheric currents, and although an average of 50 days may express numerically the visits paid annually by the copper smoke to the town, the slightest veering of the wind from the north-east point suffices to disperse or divert those clouds from it. A property of the copper smoke bearing upon the sanitary condition of the locality is, that although not specifically lighter than the atmosphere, yet, in consequence of the high temperature at which it escapes from the chimneys, it mounts high into the air. When, however, the copper smoke is mingled, and coincides in time with local mists and fogs, the surrounding atmosphere is palpably thickened, a dreary dulness spreads damply over the neighbouring scenes, and its distinctive features are recognised in its pernicious and destructive effects upon the circumjacent soil. Its effects upon vegetable existence naturally lead to enquiries as to its influences upon animal life and public health. Our author treats of the action of the copper smoke on a large extent of the surface of the soil around the northern and eastern vicinities of Swansea, so far as it affects the climate, or the health of the resident population. He considers this question resolvable into two separate propositions: the first is meteorological, and implies an altered atmospheric constitution; the second is pathological in its bearing, and concerns those meteoric conditions which favour the origin and spread of epidemic diseases. The white fumes which emanate from the chimneys and stacks of copper furnaces consist of the combined products derived from the calcination of copper, and the burning of common coal. The number of tons of copper ore annually smelted in the kingdom are estimated at about 200,000, nine-tenths of which are supposed to be manufactured at Swansea, and the coal consumed in the smelting operations of that district amounts annually to no less a quantity than 450,000 tons. The chemical compounds produced by the action of the copper smelting furnaces are scientifically examined in the essay before us—the gaseous, sulphurous, and other ingredients, which are volatilised, and the metallic contstituents which are deposited, form, in the hands of our author, matter of curious and interesting enquiry. The first part of the report concludes with the following analysis of the component parts of the copper smoke—copper, and its compounds; arsenic, and its compounds—both minute, even close to the works; sulphuric acid vapour, moderate; sulphurous acid, considerable; sublimated sulphur, minute; hydro-fluoric and fluo-siliric acids, both minute; coal smoke considerable. The professedly chemical division of the report terminates with this analysis, and we much regret that the claims upon our space prevent us from submitting the details to our readers in a more extended form, but an attentive study of the work itself will well repay those who feel particular interest in the enquiry, fully illustrated as the subject is by the researches of our author.

In the second part of the report, the entire question of the copper smoke, in relation to its disease-producing and disease-preventing agencies, is elaborately discussed. There are insuperable difficulties, which render it impracticable to study experimentally the influence, for good or for evil, which it is capable of exerting upon animal and human life; and it would appear that some, at least, of the effects which it is supposed to have upon cattle may be traced to other causes. The vocation of the copper man himself is distinguished from that of almost every other craftsman in this particular—that working in the face of an intense fire, high temperature, and its consequences, are superadded to hard labour. Exposed for twelve hours to a heat alternating between 130° and 55°, the furnace-man, working before an intense fire, or sitting in a cold draught, will constantly within that period consume a quantity varying from two to three gallons of water. This raises a curious question, applicable to many of our operatives, whether a man who loses gallons of fluid by perspiration every day throughout the year is liable to waste? Statistics, if rigorously compiled on this subject, would occupy years; but general observation, and the assurances of the men themselves, will suffice to set all doubt at rest. In all the works of the district it is quite common to find men hale, florid, and even corpulent, in personal appearance; and those who have passed 20, 30, and even 40, years before the furnace livingly solve the problem. Emaciated and lean are not more commonly met with amongst those veteran furnace-men who have perspired 600 gallons within the year, than amongst labourers in general: 50 such men lately assured our author that they were precisely the same weight as they were twelve months ago, although, as a counterpoise to such perspiration, they had consumed within that period 800 or 1000 gallons of water. The conclusion arrived at is, that the sweating of the workman labouring before the fire does not affect the frame, when that frame is saturated with water; that the nutrition of the body proceeds, even though deluged with the fluid. The fusing point of copper is 1500°, and often, in the midst of a heat radiating from such a temperature, the furnace-man works bravely for two consecutive hours, and then retires to cool himself and to drink. While direct experience supports what is physiologically reasonable, that it is by alternately drinking and sweating that the man is enabled to sustain the heat of an intensely powerful furnace, and the fatigue of very exhausting labour, indigestion is found to prevail amongst them. This our author attributes to drinking large quantities of cold water too soon after meals; but he assures us that organic diseases of the stomach are not more common amongst them than amongst other men who support themselves by their labour.

Our author places the men who work in the copper smelting furnaces above the colliers, and describes them as generally spare, erect, and muscular in personal bearing, in which last particular they stand favourably distinguished from the coal mining class. In the soldierly characteristics

of an easy carriage, manly gait, and natural freedom in movement, the copper man is prominently raised above the collier, who stands a full degree beneath him in the ethnologic scale.

The exemption of the copper districts from certain diseases is very remarkable—the furnace men are particularly free from diseased livers. The most careful enquiries into their general health have convinced the author that at no time, under any circumstances, has it been possible in their persons to discover proofs of the action of arsenic upon the body, thus refuting a general suspicion that the inhaling of that poison rendered the occupation of the copper smelter dangerous. The smoke region is rendered enviable by still more striking exemptions; for the testimony of several local medical men confirm the fact, that while typhus fever in its most malignant type raged in the country districts around Swansea, a true case of that disease has never been known in the villages immediately surrounding the works. In answering the question, what are the atmospheric or zymotic diseases which prevail in the smoke region, we are assured that the cholera only appeared in Swansea in its mildest form in 1832 and 1849, and that in this present year, while it was hurrying from life in London thousands, in Cardiff hundreds, in Merthyr and the hills scores, Swansea was spared.

The slight insight which our limits have enabled us to give into the objects and views of the author, will enable the public to estimate the value of this publication, affording most useful information—the result of deep research, attentive enquiry, and extensive experience—equally to the medical and mining community. A study, defined by the term Industrial Pathology, is beginning to attract the attention as well of the philologist as of the philanthropist, and the present publication is the most valuable contribution which it has as yet received. Our knowledge of the wants and requirements of the operative classes, and our means of ameliorating their social and improving their sanitary condition would be materially increased, if the same attention, industry, and ability, were devoted to the study of other trades, which Dr. WILLIAMS has exhibited in illustrating the industrial diseases of the mineral district of Swansea.

ON STEAM-BOILER EXPLOSIONS, AND THE EXPLOSIVE FORCE OF HIGHLY HEATED WATER.

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The frequent occurrence of disastrous boiler explosions has largely attracted scientific, practical, and popular attention, and to endeavour to guide this attention to some practical benefit is the object of this paper. The investigations which take place after explosions, chiefly turn on the magnitude of the force which produced the visible destruction. That destruction it is conceived may be readily traced to the elastic force of the body of water and steam when suddenly expanding, without ascribing it to greatly increased pressure per square inch before explosion takes place. If this can be shown satisfactorily, it will lead to more attention to evidence often discredited, because it appears at variance with the effect of the explosion, and the assumed strength of the boiler. In each instance of explosion there are two opposing forces to be estimated—first the strength of the boiler; and second, the strength of the steam. The first possesses a nearly non-elastic power of passive resistance, but the second an expansive power of vast extent, which concentrates its entire force with terrible effect on the smallest yielding of its passive opponent. Such are the antagonistic forces, and such is the difference in their relative powers; but a few remarks on each of them will render these differences more appreciable.

First, then, is the question of the real strength of the boiler. Mechanically, this depends upon the design, the materials, and the workmanship: when all three are good, a maximum strength is attained, but when any one part of them is defective, that defect rules the strength of the boiler, as bad gradients rule the tractive power of locomotives. A serious evil attends these local defects, from their becoming more acted on by the expansive and contractive motion of the boiler than the other parts. Thus slowly the cohesion of the iron is injured at these points, until some day it fails to resist a pressure it had again and again, it may be years, resisted with safety. The materials used in constructing boilers are chiefly iron and copper, and various experimenters have given reliable data of their cohesive power—of the rapid loss of strength in copper by increase of temperature, of injury to the best iron by long-sustained vibrations, and the serious loss of strength by the ordinary single riveted joints. These researches serve as guides to the designer and constructor of boilers, that the passive resistance at all points may far exceed the elastic power of the steam. The forms of boilers are so often modified by circumstances and by new plans, that no time will be occupied in discussing this part, but it is evident that, whatever the form, the materials should be of the very best quality, since the cost of labour may be the same for both good and bad materials, and the difference resolves itself into a few shillings per ton of the materials required. The best materials, and the best designs are, however, liable to injury by defective construction, for the mere economy of a little skilled labour.

Some of the chief defects in construction arise from shearing the edges of the plates, punching out the rivet holes, and drifting ill-matched rivet holes in a line by steel wedges, or "drifts," as they are technically called. These sources of injury can all be avoided by planing the edge of the plates, and boring the rivet holes when the plates are in their final position to each other. Shearing injures the fibre of the iron, and shorn strips exhibit a loss of 8 to 10 per cent. as compared with planed strips of the same iron of equal section. Punching out the rivet holes is another source of disturbance to the fibre of the iron, besides the actual loss of metal cut out, which is only made up about 3 or 4 per cent. in the fastening of the rivet head, and when rivets are over hammered, not made up at all, but, on the contrary, causes leakage. To such an extent is the aggregate of this loss, that a single rivetted joint is from 40 to 44 per cent. weaker than the plate clear of the rivets. Thus, the boiler is only about half its nominal strength, even when no injury is done to the plates by drifting the rivet holes together. It is difficult to estimate the injury done by drifting, more especially with inferior iron, since it may be carried to that extent as to cause incipient fracture between the rivet holes, and remain unseen after the rivets are fixed. In all such cases the real strength of the boiler is only a fraction of its nominal strength. The weakening effect of the rivet holes might be remedied with a thickened margin all round, so that the part left would equal the plate in strength.

Some years since the writer called the attention of a leading manufacturer of boiler plates to this description of plates, but some objections were urged as to the difficulty of rolling thick edged plates, but it cannot be an insuperable one in these days of progress. Another source of injury to boilers, and one that is seldom noticed, is the liability of the plates being subjected to chisel cuts, and the joints to caulking tool nicks. Experiments on the strength of iron have, in many instances, accidentally shown the decided loss of strength by abrasions of the surface so slight that they were not detected until the early fracture of the iron showed their injurious effect, and ordinarily little care is taken to avoid such abrasions of the surface in making boilers. With such cuts or nicks at any part of a boiler, where the vibrations of contraction and expansion are arrested by any sudden change in the thickness or the level of the surface, the fibrous structure of the iron is liable to slow but certain injury. Analogous to this source of fracture are the numerous well-known instances of railway axles breaking with more or less depth of a crystalline appearance from the surface, but with the central portion fibrous. Much discussion has taken place on this apparent conversion of iron, originally fibrous into a crystalline state, but it appears to the writer that this conversion is strictly local, and confined to a sectional line, where some change of the diameter of the axle-journal arrests the surface wave of vibration produced by the oscillation of the vehicle, so that a broken axle may exhibit a crystalline appearance at the fracture, and be quite fibrous on each side of that fracture. Generally the fracture presents a worn appearance more or less deep, next a crystalline aspect, whilst the centre shows the original fibrous structure of the axle. Incipient fracture had commenced at the surface, and attrition afterwards worn it there, whilst the steadily deteriorating vibratory concussions were destroying the fibrous iron in the line of these concussions, until fracture took place under an ordinary load, which had been safely carried many hundreds of times. It is well known to practical men that fractures chiefly occur at the angle of the journal next the wheel, and appear to be due to the waves of vibration being arrested by these angular changes of the surface. The cohesion is ultimately injured there, beginning at the surface, and gradually deepening, therefore the time of fracture will be more or less prolonged, according to the peculiar circumstance of each case. The crystallisation is thus believed to be confined to the line of fracture, where contrary currents meet, or are arrested by irregularity of surface; and if this is a correct view of the cause of these axle fractures, it shows that whenever iron has to sustain numerous constant vibrations, whether produced by motion as in railway axles, or by heat and pressure as in boilers, abrupt angles or shoulders should be avoided, so far as it is practicable to do so. If, then, the vibrations to which railway axles are subjected cause their fracture in a few years under the most ordinary circumstances, it may be fairly inferred that boiler plates are as liable to injury, by the vibrations of heat and pressure, as railway axles are to those of motion, and that a boiler plate may equally fracture under ordinary circumstances, often previously withstood. It is of obvious importance that all boilers should be carefully made and tested, and that the consequence of any defect of workmanship may be clearly understood and early discovered. Important as is a good boiler, yet with few exceptions its manufacture is in a very rude state. The engine is carefully fitted up, and where bolt holes are required additional material is given, whilst these holes are carefully drilled, but the reverse of all this takes place with boilers as commonly made. Shearing, punching, drifting, and caulking, show a very primitive mode of making boilers, and the continued use of plain boiler plates, indicates how little has been done to compensate the serious loss of 40 per cent. of the strength by the rivet holes. It is only a question of first cost, for there exists no practical difficulty in constructing a boiler as well proportioned, and as carefully put together, as the engine. And what is this cost compared to the loss caused by explosions? From what has been stated, it is evident that, as ordinarily made, the real strength of a boiler is very much less than its nominal strength, but that by an improved form of plates, and superior workmanship, the boiler might become a fitting partner to the engine in proportions, in workmanship, and in real strength. Having shown the ordinary sources of inherent weakness in boilers, and that they could be greatly improved; the antagonistic force of steam which they have to confine, comes to be considered under the second division of this subject—or the real strength of steam and water in explosions. It is usual to estimate the force of steam by its distributed pressure in the boiler, and under ordinary conditions this is correct; but an explosion introduces extraordinary conditions, by concentrating on one point the whole of the acting and expansive forces in the boiler. The steam and boiling water, in a boiler working regularly, may be compared to the gentle undulations of the tidal wave on a fine day. Each has its own atmosphere, and each its own body of water in motion. Steam is the boiler atmosphere, amongst which the water rises and falls, by disturbing causes, with equal facility as the tidal wave varies by atmospheric currents or other causes. In locomotive boilers the gauge glass gives the means to observe the full influence of gravity in an atmosphere of steam as high as of 135 lbs. per square inch, or that of nine atmospheres altogether. When this steam is suddenly cut off from the cylinder, and the velocity of the boiler is checked, the water obeys the laws of gravity and motion, by rushing forward to the front end of the boiler, with a corresponding fall at the fire-box or back end, just as a rider at full gallop is thrown forward when his horse is suddenly stopped. In a calm day the stately trees seem to defy any possible atmospheric force, yet even in our own island, the storm frequently prostrates these giants of the forest, and injures the structures of art. Neither is the strength of ships, nor the skill of the mariner, tried on a calm day, but the agitated ocean, too frequently, bears witness to the force evoked by atmospheric influence, when directed towards some common centre of disturbed equilibrium. In like-manner the boiler appears to exceed in strength the usual or assigned pressure of the steam, but then boilers are liable to defects and deterioration, whilst the steam atmosphere is liable to agitation by suddenly opening or closing the passage to the cylinders or safety valves, and producing steam currents, with their culminating points of increased pressure. Suppose, for example, that a boiler is barely able to confine the steam safely, under the most careful working, the sudden opening of the safety valve, or regulator, would induce a rush of steam to that point, and produce greater pressure directly opposite that opening than on any other part. The pressure from each end of the boiler would compress, as in a slowly closed vice, the water immediately under the opening until the boiler was emptied or burst by the increased pressure of that compressed column of water. Practically, it is also found that a great number of explosions are traceable to such agitation, and the points of fracture to either the points of opening, or immediately opposite that point. Thus a boiler, if supposed only equal to sustain the steam in its ordinary state, the increased local pressure would produce rupture, and an explosion would take place with a force measured by the elastic power of the steam, and the expansive power of the water, into steam at the same instant. The nominal pressure of the steam would bear the same relation to its explosive force, as the ordinary atmospheric pressure bears to its tempest force, since the explosive force of water is somewhat analogous to that of gunpowder, and the power of each is measured by the elastic expansion of the gases produced. The whole elastic and expansive force concentrated on one point, measures the explosive force in operation, and the amount of this force is evident by the distance to which its reaction against the part opposite to the fracture often carries the massive boiler, or destroys buildings.

An example will illustrate the extent of this force more clearly. Taking the "Lord of the Isles" locomotive, which attracted so much attention at the Exhibition of 1851, and the steam at 120 lbs. per square inch above the atmosphere, it gives an aggregate force of 17,438 tons, as calculated from the surfaces it acts against within the boiler.

Thus, the pressure on the cylindrical shell round the tubes	=1259·57 tons.
On the smoke-box tube plate	= 90·53 ,,
On the fire-box and plate	= 376·54 ,,
On the two outer sides of fire-box	= 502·07 ,,
On the outer top plate of fire-box	= 392·46 ,,
On the tube plate of fire-box	= 95·10 ,,
Total pressure on outer shell	=2716·27 tons.
Pressure on the 303 tubes, each 2 inches in diameter	=13,569·87 tons.
Pressure on the inner copper fire-box	= 1152·41 ,,
Total pressure as divided over the boiler	=17,438.55 ,,

confined in about 205 cubic feet of space, of which about 42 cubic feet are filled with team, and 163 cubic feet with water. This is the quiescent force under ordinary conditions, as it is confined in a space of about 205 cubic feet, but which on release seeks instantaneously to occupy a space of about 277,436 cubic feet, equal to atmospheric pressure, which gives some idea of the gunpowder-like expansion of steam and water in explosions. The steam expands with an elastic force equal to that of eight atmospheres, or say to 336 cubic feet, and the water to about 1700 times its own volume, or about 277,100 cubic feet, making a total volume of 277,436 cubic feet, into which they would expand at the moment of explosion. The steam produces only about 1-825th part of the expansive force, so that the explosive force of the water is by far the most formidable element in all boiler explosions.

On examining the destruction produced by some such explosion as is here supposed, it would be assumed that steam of only 120 lbs. pressure could not have torn iron as a man could tear a piece of cloth, but that enormous pressure had been produced by some neglect, or other cause. As has been shown, the nominal strength of boilers by no means indicate their real strength; any weak point giving way, however slightly, would be acted on by the steam until the elastic strength of the iron was passed, when fracture would ensue by any sudden agitation in the boiler. The point of fracture once reached, the force to be dealt with is no longer that of the divided pressure of the steam, or even its concentrated pressure in the fracture, but the explosive force of the water bursting into steam of 1700 times its volume, all directed towards that fracture, with gunpowder-like force, and gunpowder-like results.

The calm ocean and the carefully-worked boiler are relatively comparative, whilst in like manner the agitated ocean and irregularly-worked boiler are both indicative of danger, for each is subject to local atmospheric disturbance, differing only in their sphere of action, yet singularly approximating in their destructive forces. Therefore, as in the ocean storms, only the best craft, under skillful mariners, can live; so with boilers, only the best boilers, under skillful guidance, can give reasonable grounds for safety. The explosive force of the water and steam in a boiler fully accounts for the greatest exhibition of destructive power which may follow any explosion, and the view of the subject will be illustrated by referring to a few examples, chiefly amongst locomotive boilers, as the field of the author's experience. The details of most of them will be found in the Government Railway Inspectors' reports, and other points mentioned were those noted by a personal inspection of several of them after the explosion.

1. The Clyde steam-boat, the *Telegraph*, 1842. This was amongst the first of the locomotive class of boiler which burst, and caused much discussion at the time. The usual pressure was 50 lbs. per square inch, and the steam had been turned on to start the boat, when a peculiar hissing noise was heard, followed by an explosion, which projected the boiler about 60 yards from the vessel. The boiler was on Bury's plan, and the top of the inner iron fire-box was fractured, and exhibited an originally laminated plate, with several blisters on it. It was also stated that it had been twice burnt previously—that is, exposed to the fire without being covered with water, which probably caused the blisters, and greatly increased the original defect.

Here, then, the local defect, the local agitation by turning on the steam, the hissing of the breaking iron, the fracture, and the projectile force, are all distinctly attested, and all compatible with a quiescent pressure of 50 or 60 lbs. per square inch suddenly expanding to an atmospheric pressure, and acting on one point, whereby the reaction threw the boiler out of the boat into the water.

2. The "Irk" locomotive boiler, 1845. This explosion took place in the shed at Hunt's Bank, after the driver and fireman had got on the engine to take it out on duty; and as they were both killed, it is not known exactly whether the safety-valve had been tried, or the regulator opened, or not. It is, however, so usual to do one or the other, or both, in such circumstances, that it is highly probable that at least one of them was opened. As it was, the top of the inner fire-box was forced down; the brickwork of the shed under the fire-box was also forced down several inches; the engine, about 20 tons, raised through the roof, carried about 14 yds., and turned end over. The strong connection with the tender was broken, and it was also turned end over.

There is, therefore, the probable local disturbance of the steam atmosphere; the local fracture, and explosive force, also in this instance. Indeed, the local action is very distinctly remarked, as confined between the brickwork as an abutment, and the top of the outer fire-box as the centre of a projecting force, so excessive on that point as to break the strong connection to the tender, turn the tender end over, raise the engine a considerable height through the opposing roof, and land it at 14 yards distance, after having made a complete somersault, by the local reaction of the force on the heaviest end, opposite the fracture.

3. The explosion of the "Goliah" locomotive boiler, when running on the South Wales Railway, in 1850, with nearly similar results to that of the "Irk." The inner copper fire-box was forced down; the engine, broken from the tender, was raised in the air, turned end over, and carried to some distance. The engine had descended one incline, and was ascending another, when the explosion occurred. The descent would be effected with little or no steam, but which would be turned freely on to effect the ascent, causing an agitation in the boiler, and a rupture immediately below the regulator opening took place at the unsupported angle of the copper fire-box, or the weakest part in the vicinity of the disturbed steam atmosphere.

Here also the running engine exhibits precisely the same feature as the standing engine did—local disturbance, local fracture, and a local concentration of explosive force overcoming the momentum of a train in motion, so far as to break away the engine, and to turn it end over.

4. The explosion of No. 137 locomotive boiler, in 1850, at Wolverton, is an instance differing from the preceding ones, by having the regulator source of agitation about the centre of the tubular part of the boiler, and not over the fire-box. The driver had turned on the steam to start the engine when the explosion took place; and the tubular part of the boiler was laid open along the underside, and torn away from the fire and smoke-boxes, which both remained but little injured. On the top side the regulator dome was blown off, and projected to a considerable distance: the longitudinal stay rods were bent upwards, or pulled from their end fastenings; the tubes were bent downwards, and one of the wheels of the engine was forced off.

Here, again, is the local disturbance, the local rupture, and explosive force, in proportion to the greater body of water in that locality than is in the locality of the fire-box. The dome being carried away removed the local abutment, and the extensive opening below gave the explosion less of the usual projectile character, and more of the rock blast nature, than when the chief body of water has to make its way to the fracture near one end of the boiler, which, gunlike, directs the course of projection in an opposite line.

5. The Midland locomotive boiler, which had been at work six years, burst in 1850, under the most ordinary circumstances, with the fire-door open, and with a pressure of only 56 lbs. per square in. on the boiler. The fire-box top was forced down immediately after the driver had been trying the guage glass cocks, and is an instance of an explosion under circumstances which had been often previously withstood.

6. The York and North Midland boiler, which burst in 1850, when running, having the top of the copper fire-box forced down, and the engine projected about 15 yards. This boiler had also worked six years, and had doubtless often sustained the pressure which at last it failed to do.

7. The York, Newcastle, and Berwick boiler, which burst, when working, in 1850, exhibits the usual projectile force when the inner fire-box top gives way, with the addition, in this instance, of the fire-box end all blown off, followed by the smoke-door box also blown off. It was considered by Capt. Wynne, that the top of the copper fire-box had been hot, from want of water, after having it examined by experienced mechanics. Here, again, is the local defect, local rupture, and exhibition of explosive force on three different points, apparently in succession.

8. The explosion of an old stationary boiler, at Wapping, is an instance of the peculiar hissing of incipient fracture being heard in time to let the hearer escape before the destructive explosion which followed took place. The engine had been started, then stopped, when the explosion took place, clearly showing the care that should be exercised in avoiding by all possible means any agitation, especially in an old boiler, where the limit between danger and safety is very little.

9. The explosion of the locomotive boiler in Longside shed, in 1853, as ably investigated by Mr. Fairbairn. The boiler was an old one, and had run 104,723 miles. The usual pressure was 80 lbs., and the steam was observed blowing off at that pressure, previous to the driver taking charge of it, when, it was said the blowing off was stopped. It is a frequent practice to momentarily stop a safety-valve blowing off, that instructions may be heard, or orders given, and this may have led to the observed stoppage. An explosion ensued, immediately under the safety-valve: the outer plate of one side of the fire-box was blown off, and the inner fire-box bulged inwards by the reaction of the force, similarly to the brickwork at Hunt's Bank, and showing a similar localisation of concentrated force.

In this instance also the local agitation, by stopping the safety-valve, the local rupture, and the local abutment of the acting force, are as prominent as in the other examples which have been referred to, and all compatible with a moderate pressure acting on a local defect.

Extraordinary pressure, caused by tampering with the safety-valve, was one of the causes assigned for this explosion, and an investigation was ordered, under the controul of Mr. Fairbairn. This was done by testing another boiler, of the same age and class, by hydraulic pressure, when leakage began at about 110 lbs. pressure, and increased as the pressure increased. It was next ascertained that steam would rise from 80 lbs. to 108 lbs. pressure per square inch in four minutes, which is valuable, as showing the danger of stopping a safety-valve blowing off, with the best of boilers.

A flat-sided box was made, to represent the burst fire-box, and it required a pressure of 1595 lbs. per square inch to bulge the side about one-third of an inch, which gives an idea of the explosive force which bulges brickwork and strong copper plates, or carries off well-riveted domes, like a bomb-shell from a mortar.

Subsequent experiments showed that it required a force of 8·1 tons to draw out a $\frac{3}{8}$ inch iron stay, screwed into a copper plate $\frac{3}{8}$ inch thick; 7·2 tons to draw out a $\frac{3}{8}$ inch copper stay, screwed into a $\frac{3}{8}$ inch copper plate; 10·7 tons to draw out a $\frac{3}{8}$ inch iron stay, screwed and riveted into a $\frac{3}{8}$ inch copper plate; and 12·5 tons to draw out a $\frac{3}{8}$ inch iron stay, screwed and riveted into a $\frac{3}{8}$ inch iron plate.

These results correspond with the known relative strength of copper and iron, when cold; but the Franklin experimenters showed the rapid loss of strength in copper as its temperature increases. At the temperature of 328° Fahr., or 80 lbs. high pressure steam (95 lbs. gross pressure), copper had lost about 12 per cent. of its strength, when cold; while iron has rather increased its tenacity, according to the same authorities.

Mr. Fairbairn's experiments are highly valuable, as indicating the strength of a well-constructed locomotive boiler, but they only bear indirectly on local defects, whether original or produced by time, by vibration, by neglect, or by any other cause, or by a combination of causes. Thus, it is quite common to find many of the fire-box stays broken, and a part of the transverse partition of the same fire-box less than $\frac{1}{8}$ in. thick, yet safely confining water under a pressure of 120 lbs. per square inch.

There would be no comparison between the strength of the broken stays and a strip of the worn copper, yet the stays break, and the thin copper stands, exhibiting two striking practical facts for the consideration of scientific authorities.

The copper stays are found to break close to the edge of the iron plates, and appear to be liable to the same deterioration from arrested vibrations at these points, as has been ascribed to railway axles.

As copper has little more than half the tenacity of the best iron, it follows that copper stays, subjected to such concussive vibrations, would rapidly lose their cohesive tenacity, which, added to the loss of strength by the temperature, may account for their frequent failure under ordinary circumstances.

Iron stays give much greater strength, but if subjected to injurious vibrations at the edges of the plates, their ultimate fracture would be a question of time, as it is with axles. The freqnent occurrence of very thin parts in the transverse copper partitions of fire-boxes, and the absence of any known explosion at such parts, is a singular practical fact in steam-boiler experience.

Although the fracture of the stays is frequent at the sides and front end of the fire-box, yet none of the stays of the flat-sided transverse partitions have been found broken, whilst the centre of that partition itself has been worn to less than $\frac{1}{8}$ inch thick. A specimen, cut from one of these partitions, accompanies this paper, and shows the extremely small section of copper which confined water pressed to 110 lbs. above the atmosphere in a locomotive boiler, in daily work.

There is no comparison between the sectional strength of the outside copper stays, which frequently break, and that of the strip of copper from a part where no fracture has been known to occur.

The position is one subject only to the vibration of contraction and expansion of the inner fire-box, and is also remote from the usual point of steam agitation, for it scarcely admits of a doubt that on the roof of the fire-box such a thickness of copper would soon give way. The external shell of the fire-box is subject to the jars and vibrations of the frame from traction and buffing, or compression, besides those due to it as a boiler, which lead to the fracture of the stays, and other local injuries.

It is, therefore, quite possible that experiments made on two boilers, of the same age and class, might give very different results, depending upon the circumstances of each of them. However, the fellow boiler, tried by Mr. Fairbairn, began to leak at 110 lbs. pressure, and the leakage increased as the pressure was increased. A yielding of that boiler to the extent of 1-20,000th part of the volume of water would give relief, but the least yielding to steam-pressure calls into operation the expansive force of the water and steam, which follows up the elongation of any part once begun, until fracture ensues, when strong iron plates and rivetted joints are torn and twisted like the sails and rigging of a ship in a hurricane, or trees caught in a whirlwind, for the steam and atmospheric currents are alike suddenly developed, alike destructive, and alike short lived.

10. The Rochdale boiler explosion, July 1854. This is an instance of an old boiler, extra pressure, local defect over the fire, bad management, and agitation, causing a most disastrous and fatal explosion. The boiler hed been at work for eight years, was made for pressnre of 30 lbs., but urged by firing to about double that pressure, to do much more work than it was originally designed for. It was an egg-ended cylindrical boiler, about 14-horse power, and had begun to leak over the fire, but had been repaired to some extent.

Hard firing not unfrequently injures the boiler-plates most exposed to it, so that the leakage may have occurred from such injury; and the time it took to stop the leak, after the repairs showed that it had been of a partial nature, or a patch over the old plate—a dangerous mode of repair.

On the day of the explosion the boiler had been very irregularly worked; the engine started, stopped, and started again, causing renewed agitation, if not greater pressure, when the explosion occurred, with gunpowder-like destruction to all persons and property near it. The boiler appeared to have been first raised from its seat and then burst into fragments, and projected in various directions. The safety-valve piece, about 50 lbs., was projected farthest, or about 300 yards, as if it had been the first point of abutment, opposite the first fracture which raised the boiler; the whole shell of the boiler appears next to have been burst into fragments, and projected east, west, and north, by the explosion of the water into steam, with gunpowder-like rapidity and force.

Here is also the local defect, the agitation, the extra pressure, the local first fracture, indicated by the raising of the boiler, and the projected safety-valve seat, and an exhibition of explosive force so startling, that the *Times* of July 17th compares it to thunder, and to bomb-shells exploding; whilst, in his report to the jury, Mr. Fairbairn compares it to "the springing of a mine, which resulted in tearing the boiler into strips, and the destruction of everything with which it came in contact."

Ordinary fractures of one part of a boiler guide and restrain, to a certain extent, the expansion of the hot water, but when the boiler shell is laid open, as at Wolverton, in 1850, or burst into pieces, as at Rochdale, in 1854, there is no check to the instantaneous expansion of water into steam of atmospheric pressure and volume. In such cases the projectile abutment is the common centre of resistance of the expanding water and steam, similarly to gunpowder, when similarly exploded. Suppose the Rochdale boiler to have had a capacity of 300 cubic feet, of which 200 was filled with water and 100 with steam, of 60 lbs. high pressure, and a temperature of 311° Fahr., the expansion would be from 300 cubic feet to 378,300 cubic feet, all but instantaneously effected.

The boiler had been pressed far above what was considered safe for some time, and thus being strained ordinarily to the full elastic limits, it burst into eight or ten pieces, tearing the boiler-plates into strips, and destroying all around, precisely the same as if gunpowder, with an equal amount of expansive force, had been exploded.

It was considered that the pressure required to tear the boiler to pieces, as it was done, would be about 300 lbs. per square inch, but a very much greater force than this was called into action by the first beginning to rupture; and if it was considered dangerous to work the boiler to 60 lbs., it is not likely that it ever reached any such pressure as 300 lbs. per square inch, previous to the fracture.

A careful perusal of the graphic report of this explosion in the *Times* of the 17th July last, will satisfy almost any one of the explosive action of hot water under such circumstances, and may be regarded as direct proof of the views advocated in this paper, little expected, when it was written in 1851, for a treatise on locomotives, not published.

11. The Victoria boiler exposion, near Preston, 1854. The recent explosion of the Victoria steam-boat, on the Ribble, was traced to an original defect in the design and construction of the flue, after it had passed the ordinary inspection of a Government agent. Since the external appearance rarely indicates the local defect of workmanship, or plates, or design, some more satisfactory test becomes desirable than an eye inspection. Hydraulic pressure gives this test, and is easily applied. Thus, let a boiler, when made, be carefully measured by callippers externally, and the internal flues also. Then let it be pressed by water to at least 80 per cent. more than the pressure it is made to confine, and again measured by callippers.

The distortion, if any, would show the relative strength of the different parts, and thus point out local defects by altered form, or by leakage, or by both. A certificate of such test, and of the safe limit of pressure to be given, and a copy of it kept, as evidence against recklessness, by increased pressure, whenever it shonld be required.

Many other examples of explosions show how small is the limit between danger and safety, and the necessity of employing only careful, experienced men, to attend boilers: for the larger the boiler, the greater is the explosive magazine it contains, and the more dangerous any unusual agitation of its contents, caused by inattention, carelessness, or neglect.

These examples, it is hoped, will induce practical men to carefully note and report the particulars of every explosion which comes under their especial notice, that the important question of boiler explosions may be placed on a sounder basis than it has hitherto had. In all cases of judicial enquiry, this course should be adopted, and ordinary causes fully exhausted, before extraordinary ones are allowed to influence experienced men, or guide the decision of courts of law.

From what has been advanced, it is concluded:—

1. That many boiler explositions may be be traced to causes only slightly varied from those in daily operation.—2. That the real strength of a boiler is far below its nominal strength, and frequently very little above the quiescent pressure of the steam in it.—3. That the explosive force of the water and steam has the gunpowder-like power of expansion, developed after their release from confinement.

APPENDIX.

ACCOMPANYING PIECES OF COPPER.

The three thin strips of copper, about 17 inches long altogether, were cut transversely out of a locomotive fire-box partition, originally 7-16ths inch thick. At one end the strip is No. 14 wire gauge thick, at the other end No. 11, and part of it i only 17 wire gauge thick. In area, about 24 inches by 3 inches, or 72 square inches was nearly alike thin, yet safely confined water under a pressure of 110 lbs. per square inch, in daily working.

The strips of copper now sent are no solitary instance of the kind, but an example of the wear to which that class of transverse partitions appear to be subject, as thinner pieces have been taken out than this one on several occasions.

The curved top of the partition is about 8 inches above the curved line of the lowest tubes, and the wear seems to follow the same transverse line about 4 in. below the top, and mostly between the two upper rows of $\frac{7}{8}$ths inch copper stays, 4 inches apart. The thinning is, however, gradual, and extends transversely from 18 to 30 inches, and vertically from 6 to 10 inches, so that it chiefly occurs above the ordinary level of the fire, and on both sides of the partition. The samples are from the side next the tubes, where the coke could not be thrown against, and usually this side lasts double the time of the side next the fire-door. In this instance the fire-door sides had been worn down, a piece cut out, and the new piece worn again to No. 15 wire gauge thick, when both back and front had to be cut out. Out of a number of cases no instance has been seen of anything like a rupture, or even bulging, whilst on the outside shell broken stays and bulged sides are not unfrequent.

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